Conclusion: Our proposed 3D automatic contouring method achieves an accuracy of >0.8 and sensitivity of >0.7, which is comparable to the performance of manual contours clinically. We are currently working on a fully automated setup (parameters selection) of the method which is learned from a set of 3700 manually contoured treatment scans.

EP-1894

Evaluation of a novel method for automatic segmentation of rectum on daily MVCT prostate images

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Purpose or Objective: Rectal toxicity is a major complication from radiotherapy (RT) for prostate cancer. The VoxTox project aims to link rectum dose to the observed toxicity for 500 prostate cancer patients who received intensity modulated RT on TomoTherapy with daily image guidance (IG).
Rectum dose is calculated using IG megavoltage CT (MVCT) scans. MVCT images have lower soft tissue contrast and signal-to-noise ratio than conventional CT. To date, there are no auto-segmentation methods for rectum delineation on MVCT. With 200,000 rectum contours required, an experienced oncologist would need over 2 years to complete the outlining.
To automate this task, we developed an in-house auto-contouring software to outline the rectum. Our software can complete the outlining in several days.
The aim of this work is to evaluate the quality of auto-generated contours and to provide a basis for further refinement of the algorithm. The method can be extended to evaluate other auto-segmentation tools.

Material and Methods: Rectum contours were produced using a Matlab code based on 2D Chan-Vese segmentation method. The contours were overlaid on the corresponding MVCT images centred at 87 Hounsfield Units (HU) and width of 220 HU.
7110 slices from 689 daily IG MVCT scans of 20 patients were inspected by a trained doctor.
A contour quality index was defined where 1 was 'very poor' and 5 was 'very good' (clinically acceptable).
Contouring errors were categorized as
1) too large;
2) too small;
3) cut air pocket (contour cut through gas pocket in rectal lumen);
4) missed air pocket (contour excluded gas pockets);
5) shift (contour is shifted with respect to actual organ location);
6) shape (sharp corners present in contour).

Results:
Contour quality:
70% of contours were scored as "very good" (Figure 1a), and 12% were "good". 13% of contours were of "average" quality, and 4% were "poor" or "very poor".

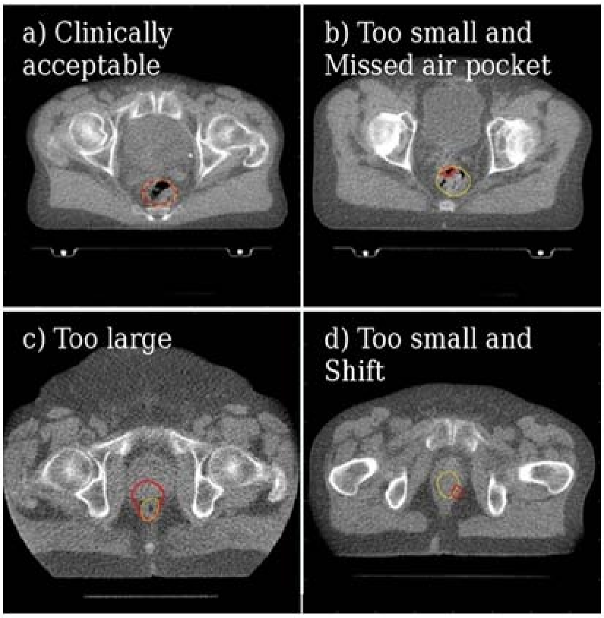

Figure 1: Auto-contoured (red line) and reference (yellow line) rectum. a) Clinically acceptable error-free contour. b),c),d): Error examples.

Error distribution:
The most frequent error was under-contouring ("too small", 21% of all reviewed images), followed by "cut air pocket" (14%). We observed an even error distribution across scans and patients (Table 1).

Error category	Prevalence across all images (n=7110)	Prevalence across scans (n = 689)	Prevalence across patients (n = 20)
Too large	5%	25%	95%
Too small	21%	68%	100%
Cut air pocket	14%	49%	100%
Missed air pocket	2%	11%	70%
Shifted	3%	18%	80%
Odd shape	3%	22%	95%
Error-free	**70%**	**14%**	**0%**

Table 1: Prevalence of errors across images and scans. Left: entire data set; centre: scans where ≥1 image has the error; right: patient data sets where ≥1 image has the error.

Conclusion: Our auto-contouring method produces clinically usable contours for the majority of cases and offers a considerable time- and resource-saving potential. We identified six error categories, four of which can be automatically detected during the auto-outlining and will drive the re-contouring process. The presented method can be used to evaluate the performance of other auto-segmentation tools for cavitary organs.

EP-1895

Towards adaptive radiotherapy: a new registration-segmentation framework for focal prostate cancer

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Purpose or Objective: Commercial treatment planning systems can combine pre-treatment magnetic resonance (MR) images with radiotherapy planning computed tomography (CT) images using rigid or non-rigid registration. However, these systems lack the ability to combine registration with automatic image analysis/segmentation methods that may be helpful in prostate cancer boost therapy when mapping of a dominant focal lesion between MR, where it is visible, and CT, where it is not visible. Here we present preliminary technical results from a new combined registration-segmentation framework for mapping of the dominant cancer foci defined on MR onto radiotherapy planning CT images in prostate cancer. The approach has the potential to be used in adaptive radiotherapy.

Material and Methods: Diagnostic MR and radiotherapy planning CT images acquired on General Electric Genesis and Signa scanners respectively were selected from 14 patients previously treated with external beam radiotherapy. Organs at risk (OAR), gross tumour volumes (GTV) and focal lesions were defined on all MR and CT images. The approach consists of two parts: 1) a rigid image registration method based on scale invariant feature transform (SIFT) and mutual information (MI); 2) a non-rigid registration method based on the cubic B-spline and a novel similarity function. Using this as prior data scale-invariant features were identified on the MR and corresponding planning CT. The mutual information (MI) between the images was used to steer the level set and thereby identify the location of the tumour and OARs on the CT based on local image information.

Results: The performance of the approach was established first by calculating similarity ratios for the rigid and non-rigid approaches in the framework (Table 1). The mean similarity ratio for the rigid approach was 67.43% and increased to 91.84% for the non-rigid approach. The registration results obtained on the GTV, OARs and focal lesion contours were assessed by an expert observer. Clinically acceptable results were found in 12 of the 14 patients and in 13 patients the non-rigid component of the framework performed better than the rigid approach. Figure 1 shows the performance in a typical case where the rigid registration approach places the focal lesion outside of the prostate and the non-rigid approach places the lesion inside of the prostate.

Case ID	Rigid registration similarity index	Non-rigid registration similarity index
1	53.26%	88.43%
2	86.24%	95.01%
4	80.45%	95.69%
5	93.22%	97.53%
6	82.84%	99.47%
7	66.32%	69.57%
8	49.95%	94.62%
9	51.28%	89.79%
11	48.27%	91.66%
12	77.64%	81.19%
13	59.73%	89.26%
14	78.36%	86.73%
15	100%	100%
16	39.36%	100%
18	44.49%	98.67%

Table 1: Similarity index obtained for rigid and non-rigid registration of the dominant focal lesion between diagnostic MR and radiotherapy planning CT.

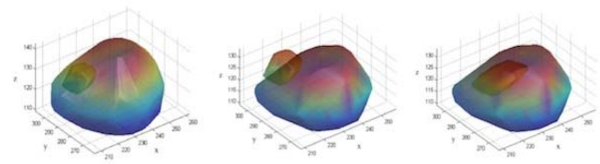

Figure 1: Left: Reconstructed prostate volume from the diagnostic MR images showing the dominant focal lesion. Middle: Reconstructed prostate volume from the radiotherapy planning CT images showing the dominant focal volume placed outside of the prostate following rigid registration. Right: Radiotherapy planning CT images showing dominant focal volume inside of the prostate following non-rigid registration.

Conclusion: This framework has the potential to track the shape variation of tumor volumes and could therefore, with more validation, be used for focal radiotherapy.

EP-1896

An atlas based auto-contouring technique incorporating interobserver variation

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Purpose or Objective: The clinical efficacy of adaptive radiotherapy requires time efficient contouring that is highly accurate to maximise the benefits of exceedingly conformal techniques. Atlas based auto-contouring is a fast, patient specific method for target volume definition however current methods fail to account for interobserver variation. Current approaches utilise a training cohort of manually defined contours, whereby the assumption is made that the manual contour is the 'gold standard' contour for that patient. A novel method of atlas-based auto-contouring that incorporates interobserver variation is presented and assessed for whole breast radiotherapy.

Material and Methods: A cohort of 28 CT datasets with whole breast CTVs delineated by eight independent observers was utilised. For optimal atlas accuracy, the cohort was divided into four categories based on mean body mass index and laterality. An average atlas was generated from all datasets but one in each category, using the MILXView platform. Observer CTVs were merged in atlas space to generate a contour probability model accounting for inter-patient and inter-observer differences. The probability model was thresholded to 50% to generate a whole breast CTV auto-contour. The time taken to auto-contour each patient was recorded. For each category, the dataset not included in atlas generation was registered to the atlas, enabling the auto-contour to be propagated and clipped to the patient surface. The auto-contour was compared to the generated 'gold truth' consensus contour generated using the STAPLE algorithm, as well as the smallest and the largest CTV for a best and worst case scenario. This comparison was performed using the Dice Similarity Coefficient (DSC) and Mean Absolute Surface Differences (MASD).

Results: The time required to auto-contour each patient was 3min, 43 sec on average. DSC and MASD of the whole breast radiotherapy auto-contour and each target volume averaged across patients in each category are presented in the table.

	DSC				MASD (mm)			
	Large Left	Large Right	Small Left	Small Right	Large Left	Large Right	Small Left	Small Right
STAPLE	0.81	0.85	0.71	0.79	7.99	3.47	6.17	5.16
Smallest CTV	0.77	0.86	0.71	0.79	9.28	3.64	4.81	5.16
Largest CTV	0.81	0.8	0.71	0.79	7.5	4.71	6.13	5.07

Conclusion: This atlas-based auto-contouring method incorporating interobserver variation was shown to be accurate (DSC>0.7, MASD <8mm for all) and efficient (time was <4min). Variations in the auto-contour and STAPLE contour occur at superior and inferior slices contributing to larger MASD values.

EP-1897

Construction of a virtual T1-weighted 4D MRI: a feasibility study

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Purpose or Objective: To derive a well-contrasted T1-weighted 4D MRI. Four-dimensional MRI is typically achieved by retrospective sorting of fast, dynamically acquired T2-weighted slices, that allow better contrast and spatio-temporal trade-off than dynamic T1-weighted acquisitions. In